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ATM Forum Technical Committee ATMF 95-1437

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Title: Benefits of AAL-Level FEC Scheme for ATM Networks

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Abstract :

This contribution discusses the benefits of AAL-level FEC (Forward Error Correction) scheme and the implementation complexity for both user's and network's point of views. Associated with all service categories (i.e., CBR, VBR, ABR, UBR), an AAL-level FEC scheme achieves some benefits, while improving the end-to-end service quality. Implementing an AAL-level FEC scheme will not require a large effort. A simple definition of additional SSCS code points would allow to indicate the use of an AAL-level FEC scheme for specific virtual circuits. For the end-systems, the support of AAL-level FEC is optional.

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1 Introduction

This contribution discusses the benefits of an AAL-level FEC scheme and the implementation complexity from user's and network's point of view. Contribution [95-0325R2] discusses benefits of an AAL-level FEC scheme for packet transmission. Contribution [95-1216] discusses the benefit of an AAL-level FEC scheme for real-time VBR video signal transmission. Contributions [95-1180] and [95-1217] discuss the benefit of an AAL-level FEC scheme, data transmission over wireless links, using ATM technology. All these contributions discuss the benefits of an AAL-level FEC scheme from point of view of a particular application or a particular environment.

This contribution clarifies the benefit of an AAL-level FEC scheme with a wider scope. Section 2 discusses the benefits of an AAL-level FEC scheme for the existing ATM service categories. Section 3 discusses the implementation complexity for an AAL-level FEC scheme from the point of view of a network provider, and from the point of view of an end system.

2 Benefits of AAL-Level FEC Scheme

2.1 Benefits for all service categories

All service categories (i.e., CBR, VBR, ABR, and UBR) can be used for both error-free data communication and error-tolerant data communication. Since

a) communication resources are shared,
b) packets are fragmented in to cells,
c) ATM is switch-based platform rather than broadcast-based platform, and
d) ATM networks will provide seamless ATM connection

across public and private networks, the following three issues will be raised.

I. Quality degradation due to the mis-behavior of end-systems.
   Though some degree of VC isolation is required for switching nodes, it may be hard to expect all nodes in a large scale internet (including public and private networks) can provide sufficient quality.
II. Quality degradation for reliable multicasting
   In a switched network, the packet error quality observed by a sender increases accroding to the product of number of receivers (N) and packet size.
   In comparison, the packet error probability of conventional, broadcast-based platforms (e.g., Ethernet, FDDI) increases much slower for a growing number of receivers. This means that the quality degradation for (reliable) multicast may be much more degraded in ATM networks than in broadcast-based platforms.
III. Quality degradation due to noisy links.
   Bit error correction should performed by the physical layer. However, some bit error patterns, such as burst bit errors, can not be recovered by the physical layer's error correction capability. When most of the burst bit error corresponds to one or two cells lengths (i.e., less than few hundread bits), an AAL-level FEC scheme can recover the burst bit errors.

2.2 CBR Service

Not to transfer cells when there is no data to be ransferred will be beneficial both for the network provider and for end-systems. The network provider can increase the resource utilization. Additionally, end-systems could reduce communication cost, if the number of transmitted cells is one parameter for communication cost.

When an application wants to have a higher service quality than provided by the network, it might decide to use FEC. Since AAL type 1 has an FEC option, designing an FEC option for CBR services based on AAL5 should also be considered. The differences between FEC for AAL1 in I.363 and AAL-level FEC scheme for AAL 5 described in [95-0326R2] are:

a) whether to need dummy data when there is no actual data to be transmitted.
b) whether the AAL provides bit-level synchronization for the application.

In cases where AAL1 (which requires to transfer dummy cells) is used for applications that perform bit-level synchronisation, it is possible to use AAL5 (which does not need to transfer dummy cells) instead. The AAL-level FEC scheme described in [95-0326R2] also does not require to transfer dummy cells. Therefore, the AAL-level FEC scheme of [95-0326R2] supports an efficient use of network resource and may reduce the number of cells transmitted cells by end-systems (i.e., it may reduce transmission costs while increasing communication quality).
However, for end-stations requiring bit-level synchronization, AAL type 1 should be used.

Note:
Network providers typically will reserve the PCR at all times for CBR services. However, users of elastic services (ABR and UBR) then will receive better service quality due to the 'generosity' of CBR users. When a user of a CBR service does transmit less cells than allowed by PCR, the resources allocated to the corresponding CBR flow may be used by an elastic service flow. This will be beneficial both for the network provider and for the users. I will be possible to use less resources without degrading the service quality. Alternatively, the quality of elastic service can be improved (or more elastic service flow could be accommodated), with the same amount of resources.
It is also possible for the service provider to allocate less bandwidth than PCR, by taking into account statistical multiplexing among CBR flows. In such a scenario, the required bandwidth for the CBR flows can be reduced, without degrading the quality of elastic services.

2.3 (Real-time and Non-real-time) VBR

VBR traffic generates data units of variable length. The benefits of an AAL-level FEC scheme for VBR are the same as the benefits for CBR discussed above.
In order to enhance the service quality, end systems may use an AAL-level FEC scheme. However, it is not appropriate for VBR services to use AAL 1 in combination with the FEC scheme defined for AAL 1, as this would require to transfer dummy cells.
Real-time VBR services typically will be used for video or voice transmission, while non-real-time VBR tends to be used for data transmission.

2.4 ABR

ABR will be able to provide sufficiently small cell loss rate (in the area of 10**-8 or 10**-6.) ABR services can be characterised by the following features:

a) it can not be expected that ABR services offer the same range of quality CBR services, due to statistical resource sharing and the latency of the control loop.
b) long-haul connection mays have multiple VD/VS along the path.
c) ABR service expects the cooperation of end-systems, according to the flow control signal (i.e., RM cell). If some end-systems do not co-operate, cell loss may occur even for the well-behaving end-systems. A certain VC isolation is required in order to avoid quality degradation due to non-cooperating end-systems.However, VC isolation will not be always perfect, and some switching systems may not be able to provide a sufficient degree of VC isolation.

ABR connections may use AAL-level FEC in the following cases:

I. large scale reliable multicast over an ATM cloud. The observed packet error probability for the sender will increase according to the product between the number of receivers and packet size.
II. high quality data transmission over an ATM-based internet, where ut can not be assumed that all switches and sub-networks provide sufficient service quality in the case of mis-bahaving end-systems. It can be expected that many switches, and many networks (in particular public networks) will provide a sufficient service qualtiy. However, networks that contain a large number of switches (both public and private) that are interconnected by P-NNI may face difficulties in providing a sufficient service quality in the presence of mis-behaving end systems.

2.5 UBR

Frame-based congestion control (e.g., ERD, Early Random Discarding) will allow to provide UBR services with a sufficiently small cell loss and frame loss rate.
However, since UBR+ERD has to expect the cooperation of end-systems, we would experience cell loss and could not obtain a sufficient quality, either when there are some end-systems that do not reduce their packet transmission rate even when experiencing packet loss, or when the control latency of the flow from which packets are selected for dropping is large.
When an application with UBR wants to improve the service quality, it may use AAL-level FEC.
When the quality degradation is not acceptable (with and without AAL-level FEC), other services than UBR should be used.

3 Implementation Complexity

There may be a concern that the increased implementation complexity increases system costs when introducing an AAL-level FEC scheme. Therefore, this section considers the implementation complexity of an AAL-level FEC scheme.

3.1 Where should FEC-SSCS be implemented ?

Some people may be concerned that an AAL-level FEC scheme increases the implementation complexity of switching nodes in the network. However, since the AAL function of user data streams is not implemented in switching nodes, there is no additional implementation complexity for switching nodes when using an AAL-level FEC scheme. Instead, the FEC scheme is implemented at the edge of the ATM network, typically being user's equipment.

3.2 Implementation complexity of FEC logic in the interface card

As discussed in contribution [95-1162] , the additional logic for implementing an AAL-level FEC scheme in hardware is not significant, compared to the logic already required for the existing AAL5 specification.

3.3 API for applications

Even when we use an AAL-level FEC scheme, we can use the existing interfaces that are already used in combination with TCP/IP and SSCOP. SSCOP may be able to solve many open issues that arise when TCP/IP is used in ATM networks. However, if the open issues of TCP/IP used in ATM networks can be solved by an AAL-level FEC scheme, it possible to keep all APIs of existing applications, without modifying the applications for the use of SSCOP. Of course, the use of SSCOP is not precluded by an AAL-level FEC scheme.
This means that, even if SSCOP will solve some issues also solved by an AAL-level FEC scheme, solving the issues using an AAL-level FEC scheme has a benefit compared to using SSCOP. When we use an AAL-level FEC scheme in combination with TCP/IP, is is sufficient to modifying just the driver (i.e., the interface between the network adapter card and the operating system).

3.4 Implementation of AAL-level FEC is optional

Since the use of an AAL-level FEC scheme will be negotiated by an end-to-end signaling procedure, receivers without AAL-level FEC functions can reject connection establish request that would require the use of an FEC scheme. In these cases, the transmitter would be able to set up a connection without FEC.

3.5 Use of existing AAL

The AAL-level FEC scheme described in [95-0326R2] does not require to define a new AAL type. SAR and CPCS of AAL 5 are not modified. This means that we do not need to pay additional effort for specifying and to implementing a new AAL.

4 Conclusion

This contribution discusses the benefits of an AAL-level FEC scheme and the implementation complexity for both end system's and network's point of views. For all service categories (i.e., CBR, VBR, ABR, UBR), an AAL-level FEC scheme achieves some benefits, while improving the end-to-end service quality. Additionally, the implementation complexity in order to introduce an AAL-level FEC scheme will not be significant.

Therefore, we propose the ATM Forum should work on the specification of an AAL-level FEC scheme in order to allow the support for higher service qualities.

5 References

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